# CLAIMS

What is claimed is:

Claim 1. An apparatus comprising:

a base assembly comprising a plurality of base legs with each adjacent pair of legs being connected by at least one leg connector assembly, each of said base legs having a bottom resilient member support and a top resilient member support attached thereto;

a driver assembly, said driver assembly being movable in a first linear direction and in an opposite linear direction and said driver assembly comprising a plurality of resilient member shafts having ends, each of which resilient member shafts has a driver to payload resilient member attached to each end thereof;

a plurality of motor assemblies comprising a motor having a motor shaft to which an eccentric mass is attached, each of said eccentric masses having a centroid, each of said motor assemblies being rigidly connected to said driver assembly and being adapted to rotate the centroid of its eccentric mass in a plane that is parallel to another plane in which said first direction and said opposite direction lie;

a payload assembly, said payload assembly being movable in the same directions as said driver assembly and being movably connected to said driver assembly by the driver to payload resilient members and being movably connected to the bottom resilient member support and the top resilient member support of said base assembly by a plurality of payload to base resilient members; and

a plurality of reaction mass assemblies, each reaction assembly being movable in the same directions as said driver assembly and being movably connected to said payload assembly by a plurality of reaction mass to payload resilient members and movably connected to said base assembly by a plurality of reaction mass to base resilient members;

wherein each of said eccentric masses has substantially the same weight and inertial properties, and wherein the eccentric masses are rotatable at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane and, during rotation, are operative to produce a first force on said driver assembly in said first direction and a second force on said driver assembly in said opposite direction and substantially no other forces on said driver assembly.

Claim 2. The apparatus of claim 1 further comprising:

four base legs;

four resilient member shafts;

four motor assemblies; and

four reaction mass assemblies.

Claim 3. The apparatus of claim 1 further comprising:

a controller that is operative to control the rotation of the motor shafts.

Claim 4. The apparatus of claim 1 further comprising:

a mixing vessel attached to said payload assembly.

Claim 5. The apparatus of claim 2 further comprising:

a motor controller that is operative to cause two of the motor shafts to rotate in a clockwise direction and two of the motor shafts to rotate in a counterclockwise direction.

Claim 6. The apparatus of claim 5 further comprising:

an accelerometer that is attached to the payload assembly or to the driver assembly, said accelerometer being operative to produce a first signal that characterizes the motion of the assembly to which it is attached.

Claim 7. The apparatus of claim 5 further comprising:

a polar position transducer that is attached to each motor shaft, each polar position transducer being operative to produce a second signal that characterizes the absolute position of the motor shaft to which it is attached.

Claim 8. A method of mixing comprising:

providing the apparatus of claim 1; and

causing the eccentric masses to rotate at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane.

Claim 9. A method of mixing comprising:

a step for providing the apparatus of claim 2;

a step for placing a composition to be mixed in said mixing chamber; and

a step for causing the eccentric masses to rotate at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane.

Claim 10. A method of mixing comprising:

a step for providing the apparatus of claim 7;

a step for placing a composition to be mixed in said mixing chamber; and

a step for causing the eccentric masses to rotate at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane.

Claim 11. An apparatus for agitation comprising:

a base;

a first movable mass, said first movable mass being movable in a first linear direction and in an opposite linear direction;

two means for rotating an eccentric mass, each of said eccentric masses having a centroid, each of said means for rotating being rigidly connected to said first movable mass and being adapted to rotate its eccentric mass in a first plane that is parallel to a second plane in which said first direction and said opposite direction lie;

a second movable mass, said second movable mass being movable in the same directions as said first movable mass and being movably connected to said first movable mass by a first resilient means and being movably connected to said base by a second resilient means; and

a third movable mass, said third movable mass being movable in the same directions as said first movable mass and being movably connected to said second movable mass by a third resilient means and movably connected to said base by a fourth resilient means;

wherein each of said eccentric masses has substantially the same weight and inertial properties, and wherein the eccentric masses are rotatable at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane and, during rotation, are operative to produce a first force on said first movable mass in said first direction and a second force on said first movable mass in said opposite direction and substantially no other forces on said first movable mass.

Claim 12. The apparatus of claim 11 further comprising:

a mixing chamber that is rigidly connected to said second movable mass.

Claim 13. The apparatus of claim 11 further comprising:

a mixing chamber that is rigidly connected to said third movable mass.

Claim 14. The apparatus of claim 11 further comprising:

first electronic or electro-mechanical means for controlling the frequency at which said second mass or said third mass moves cyclically and/or the displacement of said second mass or third mass as it moves cyclically.

Claim 15. The apparatus of claim 11 further comprising:

second electronic or electro-mechanical means for controlling the frequency at which said second mass or said first mass moves cyclically and/or the displacement of said first mass as it moves cyclically.

Claim 16. The apparatus of claim 11 wherein said resilient means have spring constants that are adjustable.

Claim 17. The apparatus of claim 11 further comprising:

electronic or electro-mechanical means for automatically adjusting the characteristics of said resilient means, the magnitudes of the forces and the frequency at which the forces are imposed, thereby allowing control of the frequency of vibration or displacement of a payload to provide consistent and/or controlled operation of the apparatus in a variety of situations.

Claim 18. The apparatus of claim 11 wherein at least some of the resilient means are selected from the group consisting of spiral springs, leaf springs, pneumatic springs, rubber springs, piezoelectric variable springs, and pneumatic variable springs.

Claim 19. The apparatus of claim 11 wherein the second mass comprises a plurality of additional masses, each of additional masses is connected to the third mass by an additional resilient means.

Claim 20. The apparatus of claim 11 wherein the third mass comprises a plurality of additional masses, each of additional masses is connected to the second mass by an additional resilient means.

Claim 21. An apparatus for agitation comprising:

a base;

a first movable mass, said first movable mass being movable in a first linear direction and in an opposite linear direction;

means for cyclically imposing forces on said first movable mass in said first direction and in said opposite direction;

a second movable mass, said second movable mass being movable in the same directions as said first movable mass and being movably connected to said first movable mass by a first resilient means and being movably connected to said base by a second resilient means; and

a third movable mass, said third movable mass being movable in the same directions as said first movable mass and being movably connected to said second movable mass by a third resilient means and movably connected to said base by a fourth resilient means;

wherein each of said means for imposing forces is operative to produce a first force on said first movable mass in said first direction and a second force on said first movable mass in said opposite direction and substantially no other forces on said first movable mass.

Claim 22. The apparatus of claim 21 further comprising:

a mixing chamber that is rigidly connected to said second movable mass.

Claim 23. The apparatus of claim 21 further comprising:

a mixing chamber that is rigidly connected to said third movable mass.

Claim 24. An apparatus for agitation comprising:

a base;

a first movable mass, said first movable mass being movable in a first linear direction and in an opposite linear direction;

a driver for cyclically imposing a force on said first movable mass in said first direction or in said opposite direction;

a second movable mass, said second movable mass being movable in the same directions as said first movable mass and being movably connected to said first movable mass by a first resilient means and being movably connected to said base by a second resilient means; and

a third movable mass, said third movable mass being movable in the same directions as said first movable mass and being movably connected to said second movable mass by a third resilient means and movably connected to said base by a fourth resilient means;

wherein said driver is operative to produce a first force on said first movable mass in said first direction or a second force on said first movable mass in said opposite direction and substantially no other forces on said first movable mass.

Claim 25. The apparatus of claim 24 further comprising:

four or more independently adjustable and controllable drivers that can be adjusted to control the vibrating force, vibrating amplitude and/or vibrating frequency of said second mass or said third mass.

Claim 26. An apparatus for agitation comprising:

a base;

a first movable mass, said first movable mass being movable in a first linear direction and in an opposite linear direction;

two means for rotating an eccentric mass, each of said eccentric masses having a centroid, each of said means for rotating being rigidly connected to said first movable mass and being adapted to rotate its eccentric mass in a first plane that is parallel to a second plane in which said first direction and said opposite direction lie;

a second movable mass, said second movable mass being movable in the same directions as said first movable mass and being movably connected to said first movable mass by a first resilient means and being movably connected to said base by a second resilient means; and

a third movable mass, said third movable mass being movable in the same directions as said first movable mass and being movably connected to said second movable mass by a third resilient means;

wherein each of said eccentric masses has substantially the same weight and inertial properties, and wherein the eccentric masses are capable of rotation at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane and, during rotation, are operative to produce a first force on said first movable mass in said first direction and a second force on said first movable mass in said opposite direction and substantially no other forces on said first movable mass.

Claim 27. The apparatus of claim 26 wherein the third movable means is connected to said base by a fourth resilient means.

Claim 28. A method of mixing comprising:

providing the apparatus of claim 11; and

causing the eccentric masses to rotate at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane.

Claim 29. A method of mixing comprising:

a step for providing the apparatus of claim 12;

a step for placing a composition to be mixed in said mixing chamber; and

a step for causing the eccentric masses to rotate at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane.

Claim 30. A method of mixing comprising:

providing the apparatus of claim 13;

placing a composition to be mixed in said mixing chamber; and

causing the eccentric masses to rotate at substantially the same rotational speed in opposite rotational directions and around axes that lie in the same plane.

Claim 31. A method of mixing comprising:

cyclically imposing a first force on a first movable mass in a first linear direction and a second force on said first movable mass in an opposite linear direction relative to a base, said first movable mass being moved in said first linear direction and then in said opposite linear direction;

the movement of said first movable mass causing movement of a second movable mass, said second movable mass being movable in the same directions as said first movable mass and

being movably connected to said first movable mass by a first resilient means and being movably connected to said base by a second resilient means;

the movement of said first movable mass or said second movable mass causing the movement of a third movable mass, said third movable mass being movable in the same directions as said first movable mass and being movably connected to said second movable mass by a third resilient means and movably connected to said base by a fourth resilient means;

the movement of said second movable mass or said third movable mass causing mixing of a composition moved by the movement of said second movable mass or said third movable mass.

Claim 32. A method of mixing comprising:

cyclically imposing a first force on a first movable mass in a first linear direction or a second force on said first movable mass in an opposite linear direction relative to a base, said first movable mass being moved in said first linear direction and then in said opposite linear direction;

the movement of said first movable mass causing movement of a second movable mass, said second movable mass being movable in the same directions as said first movable mass and being movably connected to said first movable mass by a first resilient means and being movably connected to said base by a second resilient means;

the movement of said first movable mass or said second movable mass causing the movement of a third movable mass, said third movable mass being movable in the same directions as said first movable mass and being movably connected to said second movable mass by a third resilient means and movably connected to said base by a fourth resilient means;

the movement of said second movable mass or said third movable mass causing mixing of a composition moved by the movement of said second movable mass or said third movable mass.

Claim 33. The method of claim 32 wherein the second movable mass or the third movable mass vibrates at the third harmonic and is operative to produce a force canceling effect, thereby reducing or eliminating forces transmitted to the surrounding environment and increasing mixing efficiency.

Claim 34. A process for mixing a composition that comprises a plurality of liquids; a liquid, a gas and a solid; a non-Newtonian fluid; a liquid and a gas, said process comprising:

providing the apparatus of claim 13;

placing the composition to be mixed into said mixing chamber; and

exposing the composition to a vibratory environment that is operative to vibrate the composition at a frequency between about 15 Hertz to about 1,000 Hertz and at an amplitude between about 0.02 inch to about 0.5 inch.

Claim 35. A process for mixing a composition that comprises a plurality of liquids, said process comprising:

exposing the composition to a vibratory environment that is operative to vibrate the composition at a frequency between about 15 Hertz to about 1,000 Hertz and at an amplitude between about 0.02 inch to about 0.5 inch;

thereby achieving micromixing with generation of bubbles in the range of 10 microns to 100 microns in size and enhanced uniformity of droplet size and droplet distribution.

Claim 36. A process for removing a gas from a composition comprising a liquid and a gas, said process comprising:

providing the apparatus of claim 13;

placing the composition to be mixed into said mixing chamber; and

exposing the composition to a vibratory environment that is operative to vibrate the composition at a frequency between about 10 Hertz to about 100 Hertz and at an amplitude of less than about 0.025 inch.

Claim 37. A process for removing a gas from a composition comprising a liquid and a gas, said process comprising:

exposing the composition to a vibratory environment that is operative to vibrate the composition at a frequency between about 10 Hertz to about 100 Hertz and at an amplitude between about 0.025 inch;

thereby achieving the separation of the solid and the liquid.

Claim 38. A process for increasing the rate of a reaction among reactants, said process comprising:

providing the apparatus of claim 13;

placing the reactants into said mixing chamber; and

exposing the composition to a vibratory environment that is operative to vibrate the composition at a frequency between about 10 Hertz to about 100 Hertz and at an amplitude of less than about 0.025 inch.

Claim 39. A process for increasing the rate of a reaction among reactants, said process comprising:

exposing the reactants to a vibratory environment that is operative to vibrate the composition at a frequency between about 10 Hertz to about 100 Hertz and at an amplitude between about 0.025 inch;

thereby increasing heat transfer toward or away from the reactants, mass transfer among the reactants or suspension of particles of the reactants.

Claim 40. A process for increasing the rate of intrusion or infusion of a first liquid or a gas entrained in a second liquid into a porous solid media, said process comprising:

providing the apparatus of claim 13;

placing the porous solid media or said first liquid or said gas entrained in a second liquid into said mixing chamber; and

exposing the porous solid media and first liquid or said gas entrained in a second liquid to a vibratory environment that is operative to vibrate the porous solid media and first liquid or said gas entrained in a second liquid at a frequency between about 5 Hertz to about 1,000 Hertz and at an amplitude of less than about 0.02 inch to about 0.5 inch.

Claim 41. A process for increasing the rate of intrusion or infusion of a first liquid or a gas entrained in a second liquid into a porous solid media, said process comprising:

exposing the porous solid media and first liquid or said gas entrained in a second liquid to a vibratory environment that is operative to vibrate the composition at a frequency between about 5 Hertz to about 1,000 Hertz and at an amplitude between about 0.02 inch to about 0.5 inch;

thereby breaking the boundary layer around the porous solid media and forcing said first liquid or said gas entrained in a second liquid into, out and through the porous solid media.

Claim 42. A process for mixing a biological culture that comprises a nutrient medium and a microorganism, said process comprising:

providing the apparatus of claim 13;

placing the culture to be mixed into said mixing chamber; and

exposing the composition to a vibratory environment that is operative to vibrate the composition at a frequency between about 5 Hertz to about 1,000 Hertz and at an amplitude between about 0.01 inch to about 0.2 inch.

Claim 43. A process for mixing a a biological culture that comprises a nutrient medium and a microorganism, said process comprising:

exposing the culture to a vibratory environment that is operative to vibrate the composition at a frequency between about 5 Hertz to about 1,000 Hertz and at an amplitude between about 0.01 inch to about 0.2 inch;

thereby achieving low shear mixing.

Claim 44. A process for incorporation of a solid into a liquid, said process comprising:

providing the apparatus of claim 13;

placing the solid and the liquid to be mixed into said mixing chamber; and

exposing the solid and the liquid to a vibratory environment that is operative to vibrate the composition at a frequency between about 15 Hertz to about 1,000 Hertz and at an amplitude between about 0.02 inch to about 0.5 inch.

Claim 45. A process for incorporation of a solid into a liquid, said process comprising:

exposing the solid and the liquid to a vibratory environment that is operative to vibrate the composition at a frequency between about 15 Hertz to about 1,000 Hertz and at an amplitude between about 0.02 inch to about 0.5 inch, said vibratory environment having a volume;

thereby subjecting the entire volume to a substantially equal amount of acoustic energy at the same time.